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(54) **METHOD FOR ASSOCIATING A PASS PHASE WITH A SECURED PUBLIC/PRIVATE KEY PAIR**

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(52) **U.S. Cl.** **713/168**; 713/184; 713/202
(58) **Field of Search** 713/184, 202, 713/168

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,398,285	A		3/1995	Borgelt et al.
5,511,122	A		4/1996	Atkinson
5,734,718	A		3/1998	Prafullchandra
5,768,373	A		6/1998	Lohstroh et al.
5,812,669	A		9/1998	Jenkins et al.
5,812,764	A		9/1998	Heinz, Sr.
5,825,300	A		10/1998	Bathrick et al.
5,953,422	A		9/1999	Angelo et al.
6,061,799	A	*	5/2000	Eldridge et al. 713/202
6,081,893	A	*	6/2000	Grawrock et al. 713/183
6,111,956	A	*	8/2000	Field et al. 380/283
6,170,058	B1	*	1/2001	Kausik 713/193
6,178,409	B1	*	1/2001	Weber et al. 705/79
6,230,272	B1	*	5/2001	Lockhart et al. 713/202
6,253,027	B1	*	6/2001	Weber et al. 380/287
6,324,650	B1	*	11/2001	Ogilvie 713/202
6,567,794	B1	*	5/2003	Cordery et al. 705/60
6,594,759	B1	*	7/2003	Wang 713/182
6,594,763	B1	*	7/2003	Madoukh 713/200

* cited by examiner

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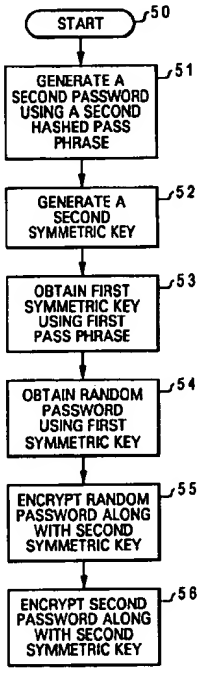
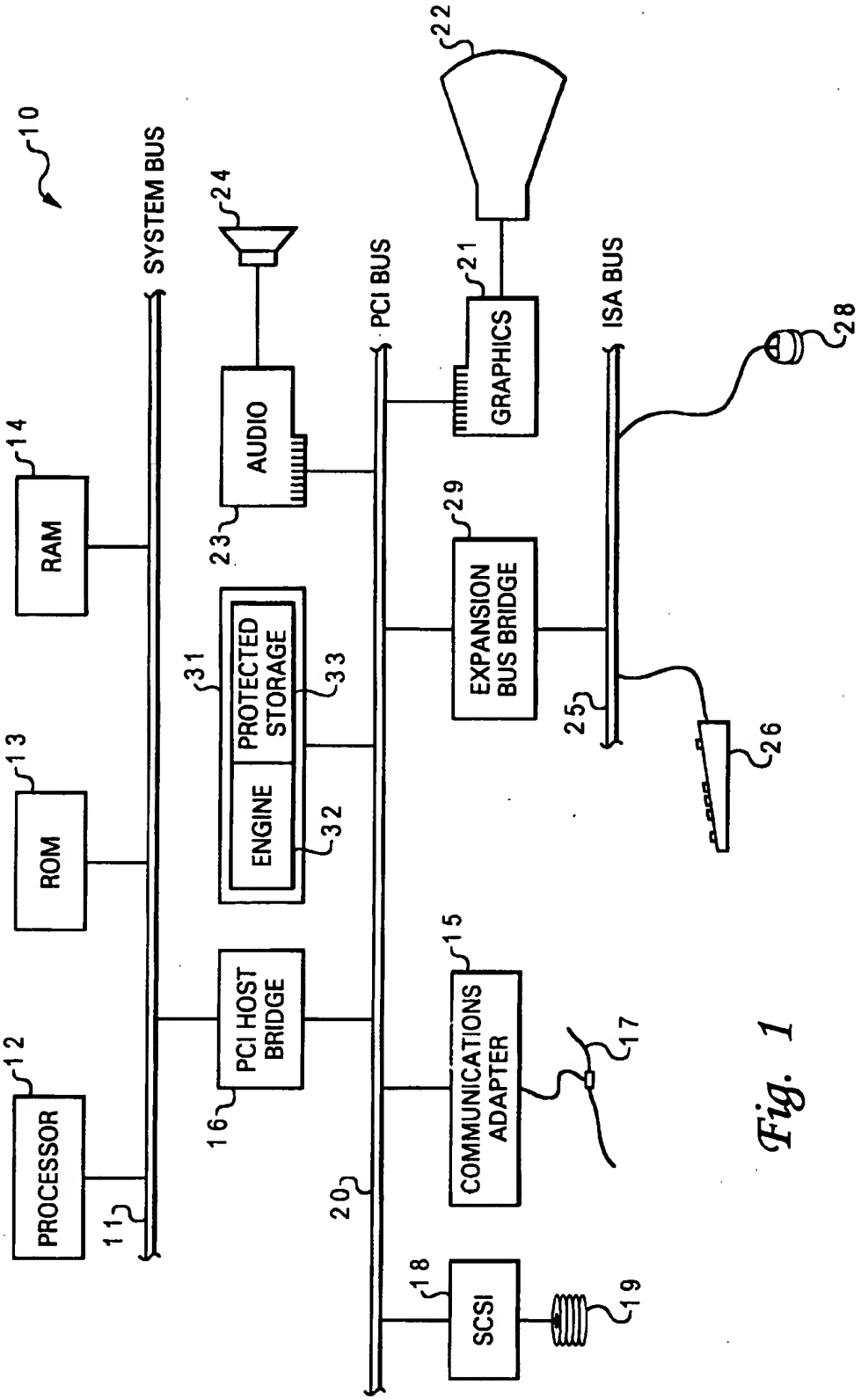
(57) **ABSTRACT**

A method for associating a pass phrase with a secured public/private key pair is disclosed. A user public/private key pair is first established for a user. The user public/private key pair includes a user public key and a user private key. Then, the user public/private key pair is encrypted along with a random password, utilizing a chip public key. Next, a first symmetric key is generated. The random password is encrypted utilizing the first symmetric key. A first password is generated by hashing a first pass phrase. Finally, the first password is encrypted along with the first symmetric key, also utilizing the chip public key. As a result, a user can access the user private key to perform an authentication function by providing the first pass phrase.

15 Claims, 2 Drawing Sheets




10
SYSTEM BUS
PCI BUS
ISA BUS
PROCESSOR
12
11
RAM
14
ROM
13
PCI HOST BRIDGE
16
AUDIO
24
23
PROTECTED STORAGE
31
33
ENGINE
32
GRAPHICS
22
21
EXPANSION BUS BRIDGE
29
25
26
28
COMMUNICATIONS ADAPTER
15
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SCSI
18
19
20

Fig. 1

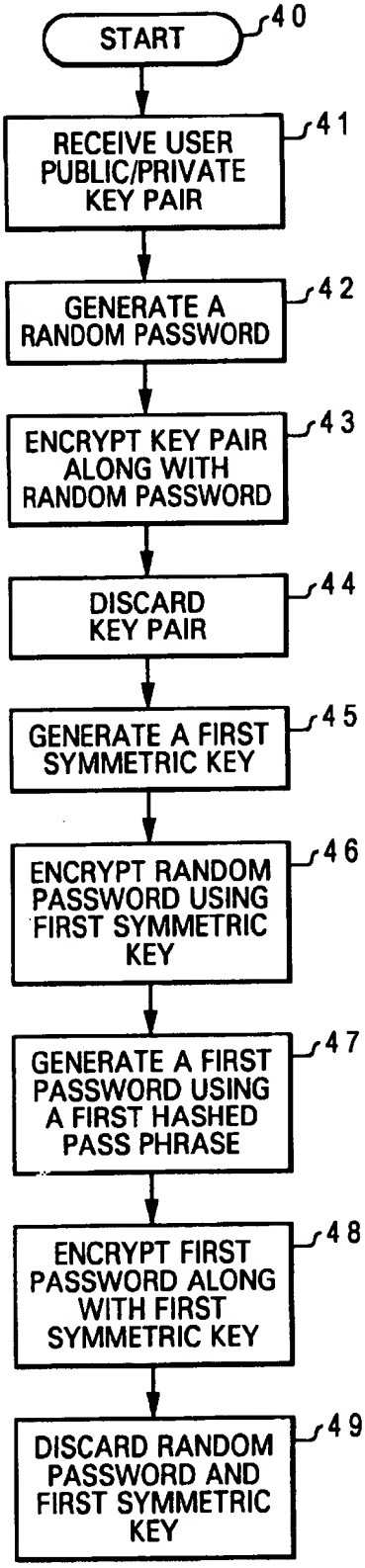
START
40
RECEIVE USER PUBLIC/PRIVATE KEY PAIR
41
GENERATE A RANDOM PASSWORD
42
ENCRYPT KEY PAIR ALONG WITH RANDOM PASSWORD
43
DISCARD KEY PAIR
44
GENERATE A FIRST SYMMETRIC KEY
45
ENCRYPT RANDOM PASSWORD USING FIRST SYMMETRIC KEY
46
GENERATE A FIRST PASSWORD USING A FIRST HASHED PASS PHRASE
47
ENCRYPT FIRST PASSWORD ALONG WITH FIRST SYMMETRIC KEY
48
DISCARD RANDOM PASSWORD AND FIRST SYMMETRIC KEY
49

Fig. 2a

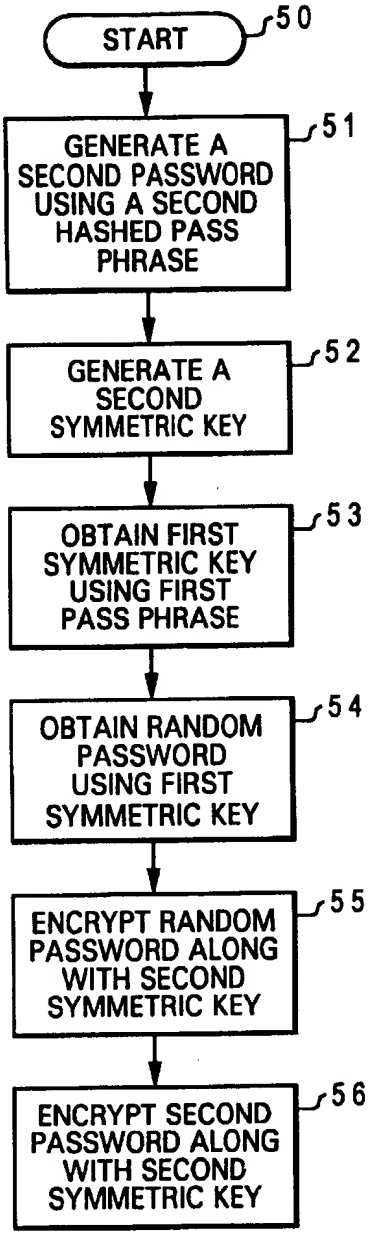
START
50
GENERATE A SECOND PASSWORD USING A SECOND HASHED PASS PHRASE
51
GENERATE A SECOND SYMMETRIC KEY
52
OBTAIN FIRST SYMMETRIC KEY USING FIRST PASS PHRASE
53
OBTAIN RANDOM PASSWORD USING FIRST SYMMETRIC KEY
54
ENCRYPT RANDOM PASSWORD ALONG WITH SECOND SYMMETRIC KEY
55
ENCRYPT SECOND PASSWORD ALONG WITH SECOND SYMMETRIC KEY
56

Fig. 2b

METHOD FOR ASSOCIATING A PASS PHASE WITH A SECURED PUBLIC/PRIVATE KEY PAIR

CROSS-REFERENCE TO A RELATED PATENT APPLICATION

The present invention is related to the subject matter of a United States Patent Application entitled "DATA PROCESSING SYSTEM AND METHOD FOR MAINTAINING SECURE USER PRIVATE KEYS IN NON-SECURE STORAGE," filed on Mar. 3, 1999, U.S. Ser. No. 09/262,123

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to a method and system for data processing in general, and in particular to a method and system for providing data security. Still more particularly, the present invention relates to a method for associating a pass phrase with a secured public/private key pair.

2. Description of the Prior Art

Cryptography involves a method for encrypting data in order to provide protection and security for the data. For example, before the transmission of a message from one party to another, the message can be encrypted using a mathematical function known as a cryptographic algorithm. The most common cryptographic algorithms are key-based, where special knowledge of variable information called a "key" is required to decrypt an encrypted message. There are two prevalent types of key-based cryptographic algorithms, namely, symmetric key (or secret key) algorithms and public key (asymmetric key) algorithms. The security provided by these cryptographic algorithms is centered around the keys and not the details of the cryptographic algorithms. In other words, the cryptographic algorithms can typically be known to all, but the keys can only be known by intended parties. As a result, it is possible to publish the cryptographic algorithm for public scrutiny, and then mass produce the cryptographic algorithm for incorporation into security products.

In most symmetric key algorithms, such as Data Encryption Standard (DES), the encryption key and the decryption key are the same. This single key encryption arrangement is not flaw-free because the sender and recipient of a message must somehow exchange information regarding the secret key. Each side must trust the other not to disclose the key. Furthermore, the sender must generally communicate the key via another relatively secure communication path (similar to a bank sending the personal identification number for an ATM card through the mail). This arrangement is not practical when, for example, the parties interact electronically for the first time over a computer network.

With public key algorithms, by comparison, the key used for encryption is different from the key used for decryption. It is generally very difficult to calculate the decryption key from an encryption key. In a typical operation, the public key used for encryption is made public via a readily accessible directory, while the corresponding private key used for decryption is known only to the recipient of the encrypted message. In an exemplary public key transaction, a sender retrieves the recipient's public key and uses it to encrypt the message prior to sending the message. The recipient then decrypts the encrypted message with the corresponding private key. It is also possible to encrypt a message using a private key and decrypt the encrypted message using a public key, which is sometimes used in digital signatures to authenticate the source of a message. of the more popular public key algorithms is RSA (named after its inventors—Rivest, Shamir, and Adleman). With RSA, when a message is encrypted utilizing a user public key, the encrypted message may only be decrypted utilizing a user private key. In one implementation, each user private key is also associated with a password, and both are enclosed within an individual secure wrapper. All user private keys along with their respective passwords are stored in a protected storage area within an encryption/decryption device, such as a signature chip. In order to allow the signature chip to perform an authentication procedure, such as signing signatures, a user must provide a correct password to the signature chip. The details of this process can be found in the above-mentioned copending application, the pertinent portion of which is incorporated by reference herein. For security purposes, it is important that no copy of any user private key exists outside the secure wrapper. Thus, a user private key and its respective password can only be unwrapped inside the signature chip, leaving no opportunity for the password to be changed. Nonetheless, for mnemonic reasons such as to allow for a password that is more memorable to a human user (the initial password is generated by a random number generator) and other security reasons such as to protect the private key after the password has been inadvertently disclosed, it is important that the password within the secure wrapper be changed periodically. The present disclosure is related to a method for associating a pass phrase with a secured user public/private key pair such that the above-mentioned problem can be resolved.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, a user public/private key pair is first established for a user. The user public/private key pair includes a user public key and a user private key. Then, the user public/private key pair is encrypted along with a random password, utilizing a chip public key. Next, a first symmetric key is generated. The random password is then encrypted utilizing the first symmetric key. A first password is generated by hashing a first pass phrase. Finally, the first password is encrypted along with the first symmetric key, also utilizing the chip public key. As a result, a user can access the user private key to perform an authentication function by providing the first pass phrase.

If the first pass phrase needs to be changed, a second password and a second symmetric key is generated. The second password is generated by hashing a second pass phrase. The first symmetric key can be obtained by utilizing the first pass phase, and the random password can then obtained by utilizing the first symmetric key. The random password is subsequently encrypted along with the second symmetric key, utilizing the chip public key. At this point, the user can access the user private key to perform the authentication function by providing the second pass phrase.

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention itself, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a block diagram of a computer system in which a preferred embodiment of the present invention is implemented;

FIG. 2*a* is a high-level logic flow diagram of a method for associating a pass phrase with a user public/private key pair, in accordance with a preferred embodiment of the present invention; and

FIG. 2*b* is a high-level logic flow diagram of a method for changing the associated pass phrase from FIG. 2*a*, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention may be utilized in a variety of computer systems under a number of different operating systems. The computer systems may be, for example, a personal computer, a mid-range computer, or a mainframe computer. In addition, the computer system may be a stand-alone system or part of a network such as a local-area network (LAN) or a wide-area network (WAN).

Referring now to the drawings and in particular to FIG. 1, there is illustrated a block diagram of a computer system in which a preferred embodiment of the present invention is implemented. As shown, a processor **12**, a read-only memory (ROM) **13**, and a Random Access Memory (RAM) **14** are connected to a system bus **11** of a computer system **10**. Processor **12**, ROM **13**, and RAM **14** are also coupled to a PCI bus **20** of computer system **10** through a PCI host bridge **16**. PCI host bridge **16** provides a low latency path through which processor **12** may directly access PCI devices mapped anywhere within bus memory and/or I/O address spaces. PCI host bridge **16** also provides a high bandwidth path allowing PCI devices to directly access RAM **14**.

Also attached to PCI bus **20** is a communications adapter **15** and a small computer system interface (SCSI) **18**. Communications adapter **15** connects computer system **10** to a local-area network (LAN) **17**. SCSI **18** is utilized to control a high-speed SCSI disk drive **19**. Expansion bus bridge **29**, such as a PCI-to-ISA bus bridge, may be utilized for coupling an ISA bus **25** to PCI bus **20**. As shown, a keyboard **26** and a mouse **28** may be attached to ISA bus **25** for performing certain basic I/O functions. In addition, an audio adapter **23** and a graphics adapter **21** may be attached to PCI bus **20**. Graphics adapter **21** controls visual output through a video monitor **22** and audio adapter **23** controls audio output through a speaker **24**.

In addition, a security device, such as a signature chip **31**, which contains an encryption/decryption engine **32** and a protected storage area **33**, is coupled to PCI bus **20**. Encryption/decryption engine **32** includes an encryption/decryption algorithm that is utilized to encode and decode messages transmitted and received by computer system **10**. Encryption/decryption engine **32** preferably performs public/private key encryption and decryption. Protected storage area **33** is utilized to store user public/private key pairs. User public/private key pairs stored within protected storage area **33** are protected by encryption/decryption engine **32** and are not directly accessible to computer system **10** or its other components. Protected storage area **33** may be implemented with an electronically erasable storage device.

Each user of computer system **10** has a separate and unique user public/private key pair established for each application within computer system **10**. The term "user" is understood to mean a person, a service, an application, a device, or any other entity that may access an application. The term "user" is not limited to a human user. A certificate may be established within computer system **10** for a user to access a particular application. The certificate may be specifically established for and associated with a particular user and a particular application. The certificate preferably includes a pointer to its associated application, an identity of the user associated with this certificate, and a pointer to the user private key associated with the user of this certificate and application. When an application needs to transmit an encrypted message or to perform an authentication procedure, encryption/decryption engine **32** accesses the user private key pointed to by the application's associated certificate, and then encrypts the message or signs a signature utilizing the user private key. reference now to FIG. 2*a*, there is illustrated a high-level logic flow diagram of a method for associating a pass phrase with a secured user public/private key pair, in accordance with a preferred embodiment of the present invention. Starting at block **40**, a user public/private key pair is first received by a signature chip such as signature chip **31** from FIG. 1, as shown in block **41**. Typically, this user public/private key pair has already been certified with the proper authority. A random password, preferably 64 bits in length, to be associated with the user public/private key pair is then generated for the user, as depicted in block **42**. This random password, which is preferably generated by a random generator, is typically very difficult for a human user to remember. Utilizing a chip public key, the random password is first encrypted along with the user public/private key pair, as shown in block **43**. The chip public key may come from an unprotected or protected storage area of the signature chip. The encrypted package of the random password and the user public/private key pair can be stored in a hard disk, such as SCSI disk drive **19** from FIG. 1. At this point, any record of the user public/private key pair outside the signature chip can be discarded (by the human user) for security reasons, as depicted in block **44**.

Next, a first symmetric key, preferably 56 bits in length, is generated utilizing a random number generator, as shown in block **45**. The random password is then encrypted utilizing the first symmetric key, as depicted in block **46**. A first password, preferably **64** bits in length, is generated utilizing a first hashed pass phrase, preferably greater than 200 bytes in length, as shown in block **47**. The first password is preferably generated utilizing a hashed pass phrase because a pass phrase permits greater permutation, and thus added security, not to mention a pass phrase is relatively easy for a human user to remember. Utilizing the chip public key, the first password is then encrypted along with the first symmetric key, as depicted in block **48**. The encrypted package of the first password and first symmetric key is then stored in the hard disk. At this point, any record of the random password and first symmetric key outside the signature chip can be discarded (by the human user) for security reasons, as illustrated in block **49**.

During operation, a first pass phrase sent by a user is hashed by a processor, such as processor **12** in FIG. 1, in a system memory, such as RAM **14** in FIG. 1, to obtain its corresponding first password. This first password along with the encrypted package of the first password and first symmetric key (from the hard disk) are then sent to the signature chip. The signature chip decrypts the encrypted package of the first password and first symmetric key. The signature chip then compares the first password from the decrypted package of the first password and first symmetric key with the sent first password. The signature can use the first symmetric key in the decrypted package if both first passwords match with each other. Because the first symmetric

key is much less than 1,024 bits, the signature chip recognizes that the first symmetric key is not a signature key (i.e., the user private key of the user public/private key pair), and hence exports the first symmetric key to the system memory. The processor utilizes the first symmetric key to decrypt the random password. The random password is subsequently sent to the signature chip along with a copy of the encrypted user public/private key pair stored in the hard drive to authorize the signature chip to perform a signatory function using the user private key.

With reference now to FIG. **2***b*, there is illustrated a high-level logic flow diagram of a method for changing the associated pass phrase from FIG. **2***a*, in accordance with a preferred embodiment of the present invention. Starting at block **50**, a second password is generated by hashing a second pass phrase, as shown in block **51**. Similar to the first pass phrase from block **47** of FIG. **2***a*, the second pass phrase is chosen by the human user and it should be for the human user to remember. Next, a second symmetric key is generated, as depicted in block **52**. The first pass phrase (i.e., the old pass phrase) is sent by the user to the processor to hash, and the hashed result (i.e., the first password) is sent to the signature chip along with a copy of the encrypted package of the first password and first symmetric key to obtain the corresponding first symmetric key from the signature chip, as depicted in block **53**. The random password is then decrypted by utilizing the first symmetric key, as depicted in block **54**. The random password is then encrypted utilizing the second symmetric key, as illustrated in block **55**. Utilizing the chip public key, the second password is then encrypted along with the second symmetric key, as illustrated in block **56**. The encrypted package of the second password and second symmetric key is subsequently stored in the hard disk. As such, the first (old) pass phrase for accessing the user private key to provide an authentication function has been replaced by the second (new) pass phrase.

As has been described, the present invention provides an improved method for associating a pass phrase with a secured user public/private key pair. Although a random password is preferably encrypted with both user public and private keys (as shown in block **43** of FIG. **2***a*), it is sufficient to encrypt the password and only the user private key from the user public/private key pair.

It is also important to note that although the present invention has been described in the context of a fully functional computer system, those skilled in the art will appreciate that the mechanisms of the present invention are capable of being distributed as a program product in a variety of forms, and that the present invention applies equally regardless of the particular type of signal bearing media utilized to actually carry out the distribution. Examples of signal bearing media include, without limitation, recordable type media such as floppy disks or CD ROMs and transmission type media such as analog or digital communications links.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method for associating a pass phrase with a secured user public/private key pair within a computer system, said method comprising:

establishing a user public/private key pair for a user, wherein said user public/private key pair includes a user public key and a user private key;

encrypting said user private key along with a random password;

generating a first symmetric key;

encrypting said random password utilizing said first symmetric key;

generating a first password by hashing a first pass phrase;

encrypting said first password along with said first symmetric key;

utilizing said first pass phrase to access said user private key for performing an authentication function;

generating a second password by hashing a second pass phrase;

generating a second symmetric key;

encrypting said random password utilizing said second symmetric key;

encrypting said second password along with said second symmetric key; and

utilizing said second pass phrase to access said user private key for performing an authentication function.

2. The method according to claim **1**, wherein encrypting said user private key along with said random password is performed utilizing a chip public key.

3. The method according to claim **1**, wherein encrypting said first password along with said first symmetric key is performed utilizing a chip public key.

4. The method according to claim **1**, wherein encrypting said user private key along with a random password further includes encrypting said user private key and said random password along with said user public key.

5. The method according to claim **1**, wherein encrypting said second password along with said second symmetric key is performed utilizing a chip public key.

6. A computer system having a password associated with a secured user public/private key pair, said computer system comprising:

means for establishing a user public/private key pair for a user, wherein said user public/private key pair includes a user public key and a user private key;

means for encrypting said user private key along with a random password;

means for generating a first symmetric key;

means for encrypting said random password utilizing said first symmetric key;

means for generating a first password by hashing a first pass phrase;

means for encrypting said first password along with said first symmetric key;

means for utilizing said first pass phrase to access said user private key for performing an authentication functions;

means for generating a second password by hashing a second pass phrase;

means for generating a second symmetric key;

means for encrypting said random password utilizing said second symmetric key;

means for encrypting said second password along with said second symmetric key; and

means for utilizing said second pass phrase to access said user private key for performing an authentication function.

7. The computer system according to claim **6**, wherein means for encrypting said user private key performs an encryption utilizing a chip public key.

8. The computer system according to claim 6, wherein means for encrypting said first password performs an encryption utilizing a chip public key.

9. The computer system according to claim 6,wherein means for encrypting said user private key along with a random password further includes a means for encrypting said user private key and said random password along with said user public key.

10. The computer system according to claim 6, wherein means for encrypting said second password along with said second symmetric key is performed utilizing a chip public key.

11. A computer program product for associating a pass phrase with a secured user public/private key pair within a computer system, said computer program product comprising:

program code means for establishing a user public/private key pair for a user, wherein said user public/private key pair includes a user public key and a user private key;

program code means for encrypting said user private key along with a random password;

program code means for generating a first symmetric key;

program code means for encrypting said random password utilizing said first symmetric key;

program code means for generating a first password by hashing a first pass phrase;

program code means for encrypting said first password along with said first symmetric key;

program code means for utilizing said first pass phrase to access said user private key for performing an authentication functions;

program code means for generating a second password by hashing a second pass phrase;

program code means for generating a second symmetric key;

program code means for encrypting said random password utilizing said second symmetric key;

program code means for encrypting said second password along with said second symmetric key; and

program code means for utilizing said second pass phrase to access said user private key for performing an authentication function.

12. The computer program product according to claim 11, wherein program code means for encrypting said user private key performs an encryption utilizing a chip public key.

13.The computer program product according to claim 11, wherein program code means for encrypting said random password performs an encryption utilizing a chip public key.

14. The computer program product according to claim 11, wherein said program code means for encrypting said user private key along with a random password further includes encrypting said user private key and said random password along with said user public key.

15. The computer program product according to claim 11, wherein said program code means for encrypting said second password along with said second symmetric key is performed utilizing a chip public key.

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